

# Submicron Resolution X-ray Spectroscopy Beamline (SRX)

## Scientific Scope

Scientific communities such as environmental sciences, life sciences, and material sciences have identified the need to develop analytical resources to advance the understanding of complex natural and engineered systems that are heterogeneous on the micron to nanometer scale. These needs for high intensity x-ray nanoprobe resulted in the commitment of the NSLS-II Project to build the Submicron Resolution X-Ray (SRX) Spectroscopy beamline showing a unique combination of high spectral resolution over a very broad energy range and very high beam intensity in a sub-micrometer spot. NSLS-II will provide one of the best sources in the world for such an instrument. The research topics to be addressed require characterization of elemental abundances and speciation in samples that are heterogeneous at the sub-micrometer scale.

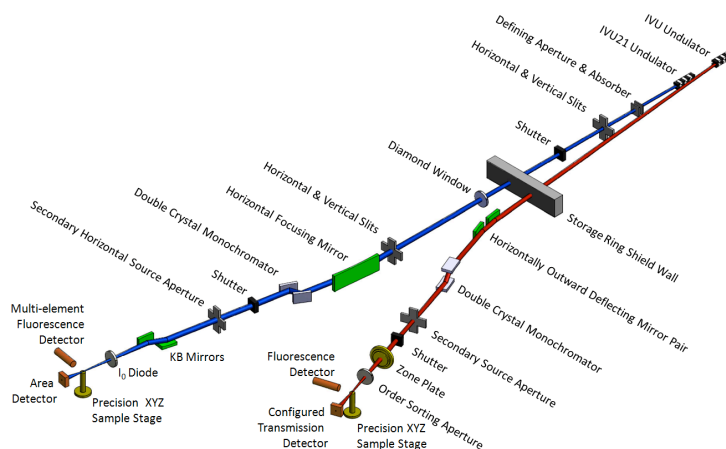
## Beamline Description

The design shows a canted undulator beamline that consists of two branches, each optimized to reach very high spatial resolution for a specific energy range. The first branch is optimized to access higher energy and is included in the initial scope of NSLS-II for the SRX beamline. It will access an energy range of  $E = 4.65 \text{ keV}$  to  $E = 25 \text{ keV}$ . Two sets of Kirkpatrick-Baez (KB) mirror optics will focus the beam creating either a sub-micrometer sized focal spot at high flux or a sub-100 nm spot at moderate flux. A swap between the two setups will be possible in a couple of minutes. The second branch, optimized for lower energies, accessing spectroscopic edges from  $E = 2 \text{ keV}$  to  $E = 15 \text{ keV}$ , will require additional funding to be completed. Zone plates (ZP) will be used as focusing optics for this branch, creating a focal spot below 30 nm.

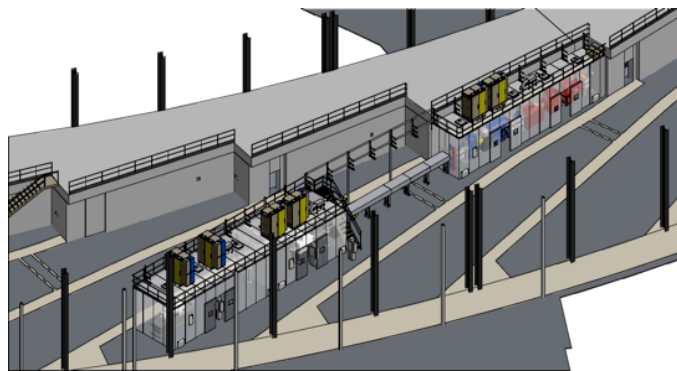
The wide energy range covered by both branches will allow the scientific community to address a wide range of research topics, as absorption edges of a large number of elements

The periodic table shows elements highlighted in orange, indicating they have an absorption edge in the energy range covered by SRX. The highlighted elements include: H, He, Li, Be, B, C, N, O, F, Ne, Na, Mg, Al, Si, P, S, Cl, Ar, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Kr, Rb, Sr, Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb, Te, I, Xe, Cs, Ba, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Fr, Ra, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr. The table also includes element names, symbols, atomic numbers, and atomic weights.

**Figure 1** Periodic table showing elements highlighted that have an absorption edge in the energy range covered by SRX and are therefore accessible for microspectroscopy



**Figure 2** Schematic representation showing the optic layout of the SRX beamline.



**Figure 3** 3D CAD model of the SRX beamline showing the first optical enclosure (right) and the two endstation hutches for KB and ZP branches (left and middle)

## Conceptual Design Report

can be reached with the SRX beamline, allowing elemental mapping as well as spectroscopy studies (see Figure 1). The two branches are required to cover this large energy range without compromising the aim of combining X-ray spectroscopy and sub-micron spatial resolution in an optimal way.

### Techniques Available

- X-ray absorption imaging
- X-ray fluorescence imaging
- X-ray tomography
- X-ray fluorescence trace element mapping
- XANES absorption spectroscopy
- XANES fluorescence spectroscopy
- X-ray spectromicroscopy
- X-ray microdiffraction

### Beamline Performance (KB branch)

Source	In-vacuum undulator, l = 21 mm, L = 1.5 m
Energy range	$4.65 \text{ keV} \leq E \leq 25 \text{ keV}$
Monochromator	Horizontally deflecting DCM, Si (111), Si (311)
Energy resolution	DE $\approx 1.5\text{-}2.5 \text{ eV}$ @ 12 keV DE $\approx 0.08\text{-}0.7 \text{ eV}$ @ 7 keV
Focal spot size and flux for moderate- resolution setup	$1.0 \times 0.8 \mu\text{m}^2$ (H x V) at $1.3 \cdot 10^{13}$ phot/sec tunable to $0.8 \times 0.8 \mu\text{m}^2$ (H x V) at $0.9 \cdot 10^{13}$ phot/sec
Focal spot size and flux for high- resolution setup	$140 \times 60 \text{ nm}^2$ (H x V) at $10^{12}$ phot/sec tunable to $60 \times 60 \text{ nm}^2$ (H x V) at $0.6 \cdot 10^{12}$ phot/sec

### Sample environment

Beginning with thin sections from geosciences over micro- and nanoparticles in suspensions to microbial or biological specimens, the sample stage will be able to accommodate a great variety of samples from different scientific areas. Experiments will start under ambient conditions; a cryo stage is anticipated.

### Contact

**Juergen Thieme** [jthieme@bnl.gov](mailto:jthieme@bnl.gov)

### Beamline Personnel

**Vincent deAndrade** [jthieme@bnl.gov](mailto:jthieme@bnl.gov)

**Juergen Thieme** [jthieme@bnl.gov](mailto:jthieme@bnl.gov)

**Yuan Yao** [yyao@bnl.gov](mailto:yyao@bnl.gov)

### Beamline Advisory Team

**Peter Eng**, University of Chicago

**Jeffrey Fitts**, Brookhaven National Laboratory

**Chris Jacobsen**, Northwestern University

**Keith Jones**, Brookhaven National Laboratory

**Antonio Lanzirotti**, University of Chicago

(spokesperson)

**Lisa Miller**, Brookhaven National Laboratory

**Matt Newville**, University of Chicago

**Paul Northrup**, Brookhaven National Laboratory

**Richard Reeder**, Stony Brook University

**Mark Rivers**, University of Chicago

**Stephen Sutton**, University of Chicago

**Stefan Vogt**, Argonne National Laboratory

**Gayle Woloschak**, Northwestern University

**Current status:** preliminary design

**Construction:** starts Jan. 2012

**Commissioning:** begins Feb. 2014

**User Operation:** begins June 2015